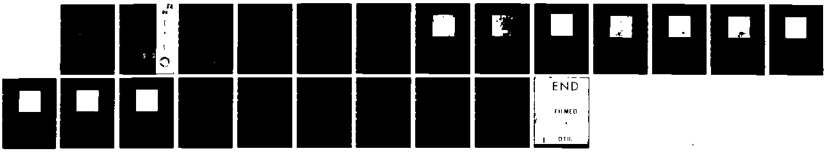
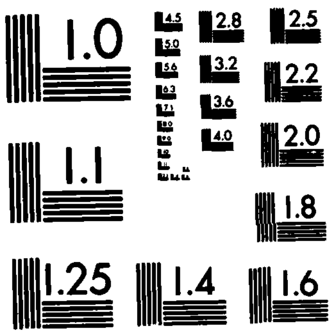
AD-A123 496 SCENE CLASSIFICATION RESULTS USING THE MAX-MIN TEXTURE MEASURE(U) ARMY ENGINEER TOPOGRAPHIC LABS FORT BELVOIR VA M A CROMBIE ET AL. JUL 82 ETL-0300 1/1

UNCLASSIFIED F/G 14/5 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD A 123496

ETL-0300

8

Scene classification results using the max-min texture measure

Michael A. Crombie

Robert S. Rand

Nancy J. Friend

E T L

JULY 1982

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060

83 01 18 017

PREFACE

This study was conducted under DA Project 4A762707A855, Task B, Work Unit 00026, "Topograhic Mapping Techniques."

The study was done during 1981 under the supervision of Mr. Dale E. Howell, Chief, Information Sciences Division; and Mr. Lawrence A. Gambino, Director, Computer Sciences Laboratory.

COL Edward K. Wintz, CE was Commander and Director and Mr. Robert P. Macchia was Technical Director during the report preparation.

CONTENTS

ILLUSTRATIONS

TABLES

SCENE CLASSIFICATION RESULTS USING THE MAX-MIN TEXTURE MEASURE

INTRODUCTION

Results from a previous analysis by ETL indicated that the Max–Min texture measure was practical and showed promise of being an efficient tool for image segmentation.[1,2] Probabilistic relaxation was applied to the results in order to remove ambiguities and to remove noise.[3] Results from the relaxation process were also encouraging and it was decided that both processes, i.e., the classification using Max–Min texture followed by a relaxation of the output, would be applied to full scenes to determine if the techniques were still applicable. Note that tests in the referenced experiment were limited to regions selected to train the process.

NUMERICAL EXPERIMENT

Because of the very long computer processing times, only 2 scenes were analyzed in this experiment; whereas, 10 scenes were analyzed in the referenced ETL experiment (ETL-0280). The results of the previous tests pertained only to the test regions; whereas, the results of this experiment pertain to a dense network of pixels over the entire scene.

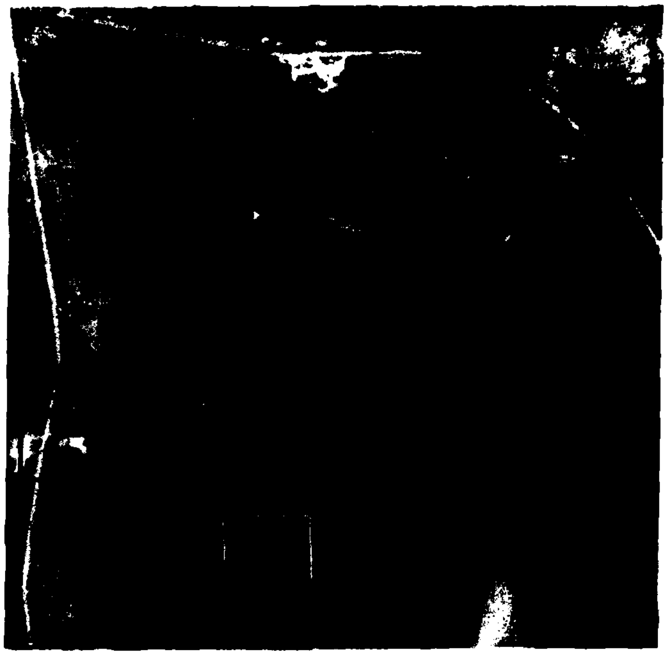
Input Data ● Every fifth pixel and every fifth line of panchromatic scenes A and B shown in figures 1 and 2 were classified by applying the Maximum Likelihood Classifier to a 14–component Max–Min texture vector described in Research Note ETL-0280. The Max–Min texture vector was extracted from a 15 x 15 window centered over the pixel in question. The three most likely classifications along with associated probabilities were calculated for each pixel. The probabilities were used as input to a relaxation process (also described in ETL–0280). The required statistics for the classification exercise were derived from the training regions. The six defined classes are outlined by the rectangles shown on the images in figures 1 and 2. Note that the scenes are 1024^2 x 8 bits and that the ground resolution (line and pixel spacing) is about 1 meter.

---

[1] Michael A. Crombie, Robert S. Rand, and Nancy J. Friend, *An Analysis of the Max–Min Texture Measure,* U.S. Army Engineer Topographic Laboratories, Fort Belvoir, VA, January 1982, ETL–0280.

[2] Owen R. Mitchell, Charles R. Myers, and William Bayne, "A Max-Min Measure for Image Texture Analysis," *IEEE Trans. Comput.,* Vol. C–25, April 1977.

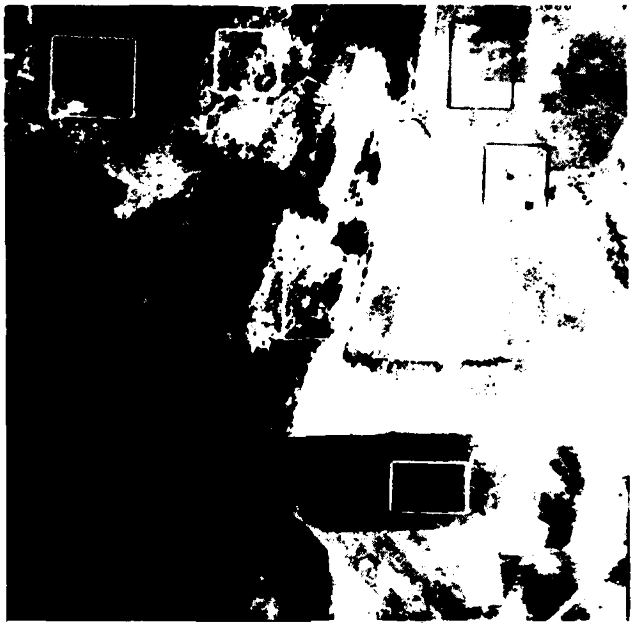
[3] Azriel Rosenfeld, Robert A. Hummel, and Steven W. Zucker, "Scene Labeling by Relaxation Operations," *IEEE Transactions on Systems, Man, and Cybernetics,* Vol. SMC–6, June 1976.



CLASS	TYPE
1	Building and Road
2	Gray Field
3	Rough Field
4	Heavy Forest
5	Light Field
6	Light Forest

FIGURE 1. Scene A.

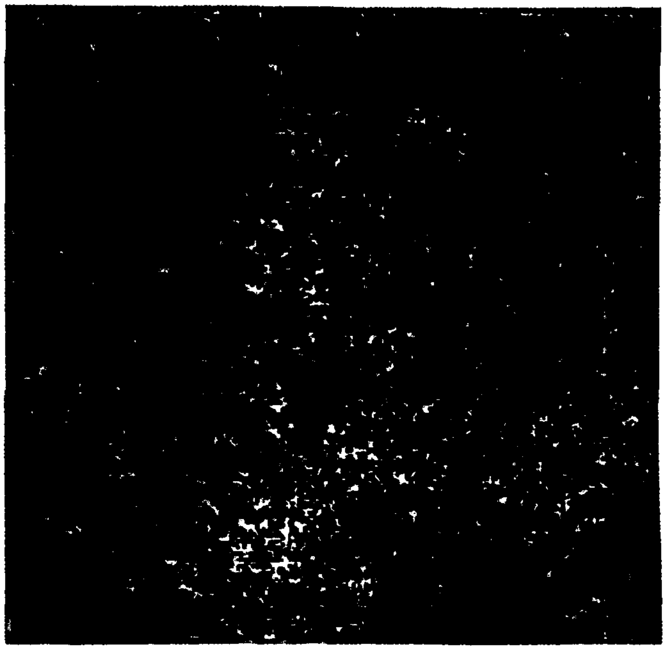
FIGURE 1. Scene A.



CLASS	TYPE
1	Heavy Forest
2	Scrub
3	Field, Building, and Road
4	Dark Field
5	Light Field
6	Light Forest

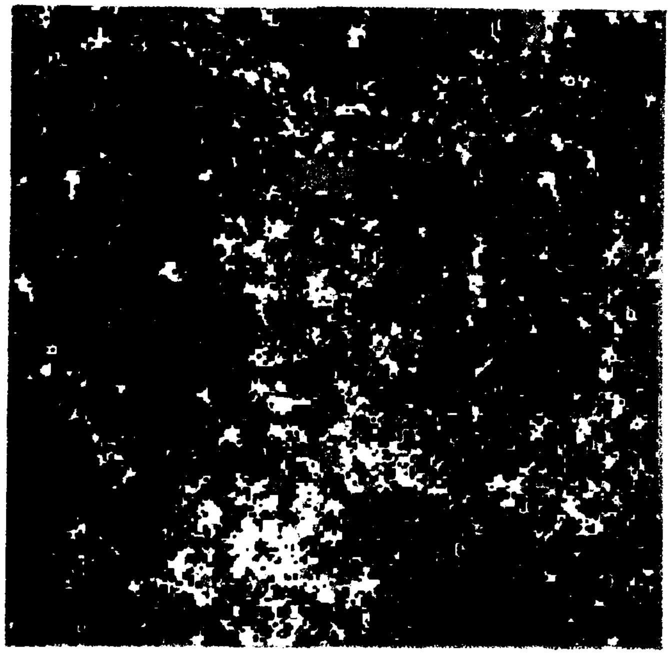
FIGURE 2. Scene B.

Results • Pictorial results are presented in figures 3 to 10. Each classified pixel was enlarged to a 5 x 5 blob, and then displayed on a TV screen. The various classification results were color coded for viewing. For example, figure 3 depicts results for Scene A and figure 4 depicts a relaxed version of figure 3 after six probabilistic relaxation iterations. Figures 5 and 6 depict comparable results for Scene B.



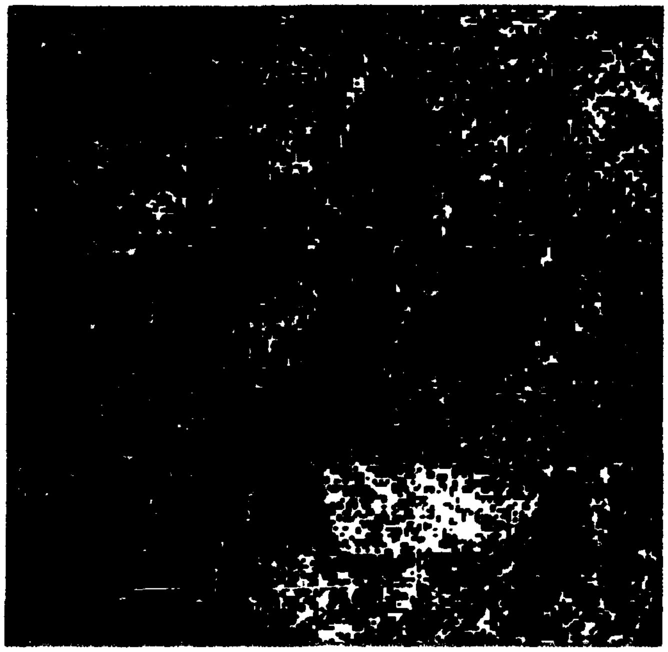
CLASS	TYPE	COLOR
1	Building and Road	Red
2	Gray Field	Yellow
3	Rough Field	Black
4	Heavy Forest	Blue
5	Light Field	Green
6	Light Forest	White

FIGURE 3. Classification Results of Scene A.



CLASS	TYPE	COLOR
1	Building and Road	Red
2	Gray Field	Yellow
3	Rough Field	Black
4	Heavy Forest	Blue
5	Light Field	Green
6	Light Forest	White

FIGURE 4. Relaxed Results of Scene A.

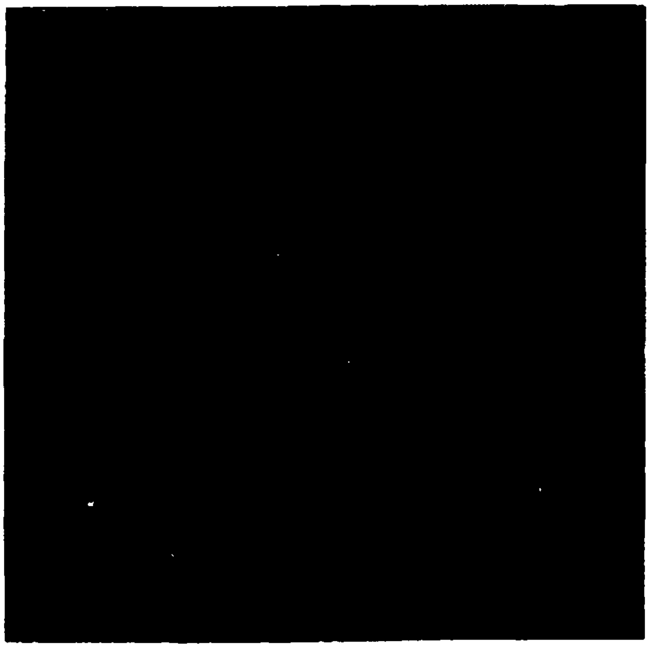


CLASS	TYPE	COLOR
1	Heavy Forest	Red
2	Scrub	Green
3	Field, Building, and Road	Blue
4	Dark Field	White
5	Light Field	Black
6	Light Forest	Yellow

FIGURE 5. Classification Results of Scene B.

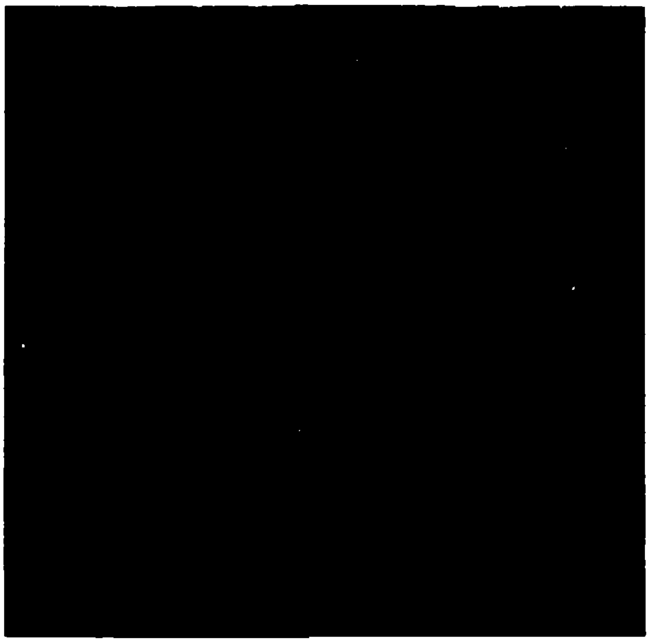
CLASS	TYPE	COLOR
1	Heavy Forest	Red
2	Scrub	Green
3	Field, Building, and Road	Blue
4	Dark Field	White
5	Light Field	Black
6	Light Forest	Yellow

FIGURE 6. Relaxed Results of Scene B.



CLASS TYPE	COLOR
Building and Road	Red
Forest	Blue
Field	Green

FIGURE 7. Combined Results of Scene A.

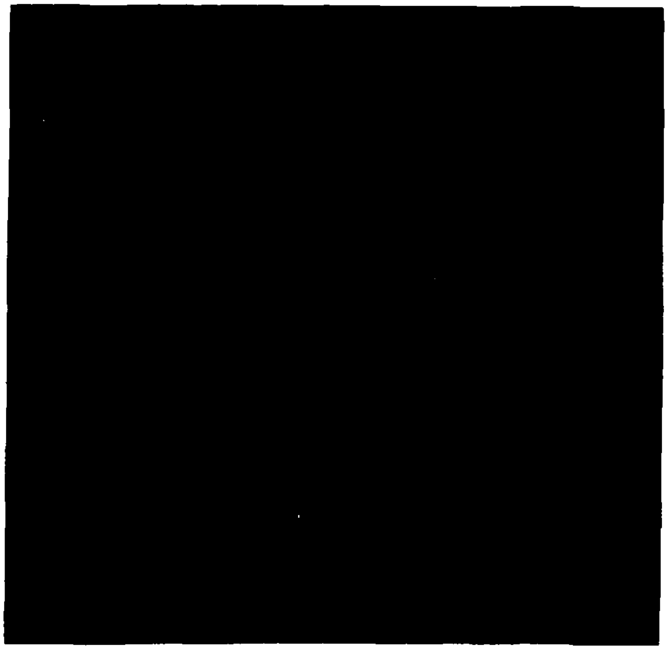


CLASS TYPE	COLOR
Building and Road	Red
Forest	Blue
Field	Green

FIGURE 8. Combined Relaxed Results of Scene A.

CLASS TYPE	COLOR
Field, Building, and Road	Red
Forest	Blue
Field	Green

FIGURE 9. Combined Results of Scene B.



CLASS TYPE	COLOR
Field, Building, and Road	Red
Forest	Blue
Field	Green

FIGURE 10. Combined Relaxed Results of Scene B.

Each of the scene results was reduced to three classes by combining comparable classes. For example, figure 7 depicts results for Scene A where the three field classes are presented as a single class and the two forest classes are combined and presented as a single class. The same operation was applied to the relaxed version of Scene A and the result is shown in figure 8. Figures 9 and 10 depict comparable results for Scene B.

Numerical comparisons between relaxation results from this experiment and the previous experiment can be made by evaluating results over the test regions. The confusion matrices for the maximum likelihood classification should be (they were) identical to those of the previous experiment. The results for Scene A are presented in tables 1 and 2, and those for Scene B are presented in tables 3 and 4.

TABLE 1. Confusion Matrices for Scene A

Maximum Likelihood Results

CLASS	1	2	3	4	5	6
1	67.9	6.2	2.5	7.4	9.9	6.2
2	0.0	88.9	0.0	1.4	8.3	1.4
3	4.8	1.0	61.5	12.5	9.6	10.6
4	0.0	1.2	0.0	95.2	2.4	1.2
5	0.0	7.9	0.0	1.6	82.5	7.9
6	1.9	5.6	3.7	20.4	8.3	60.2

Relaxation Results

CLASS	1	2	3	4	5	6
1	86.4	4.9	0.0	1.2	6.2	1.2
2	0.0	98.6	0.0	0.0	1.3	0.0
3	4.8	0.0	74.0	9.6	9.6	1.9
4	0.0	0.0	0.0	100.0	0.0	0.0
5	0.0	1.5	0.0	0.0	98.4	0.0
6	0.0	3.7	0.9	12.0	4.6	78.7

TABLE 2. Confusion Matrices for Combined Results of Scene A

Maximum Likelihood Results

CLASS	A	B	C
A	67.9	9.9	22.2
B	2.7	83.5	13.8
C	0.8	11.5	87.7

Relaxation Results

CLASS	A	B	C
A	86.4	1.2	12.4
B	2.6	91.0	6.4
C	0.4	5.8	93.8

Class A. Building and Road
Class B. Forest
Class C. Field

TABLE 3. Confusion Matrices for Scene B

Maximum Likelihood Results

CLASS	1	2	3	4	5	6
1	96.7	1.7	0.8	0.0	0.8	0.0
2	29.3	58.6	3.0	2.0	4.0	3.0
3	6.2	2.5	79.0	3.7	3.7	4.9
4	0.0	0.0	0.0	94.8	5.2	0.0
5	0.0	0.0	2.6	10.3	85.5	1.7
6	22.2	4.9	1.2	1.2	6.2	64.2

TABLE 3. Confusion Matrices for Scene B (Continued)

Relaxation Results

CLASS	1	2	3	4	5	6
1	100.0	0.0	0.0	0.0	0.0	0.0
2	34.3	56.6	0.0	2.0	7.1	0.0
3	3.7	1.2	76.5	3.7	14.8	0.0
4	0.0	0.0	0.0	96.1	3.9	0.0
5	0.0	0.0	0.0	2.6	97.4	0.0
6	34.6	0.0	0.0	0.0	6.2	59.3

TABLE 4. Confusion Matrices for Combined Results of Scene B

Maximum Likelihood Results

CLASS	A	B	C
A	79.0	13.6	7.4
B	1.7	94.0	4.3
C	1.6	1.0	97.4

Relaxation Results

CLASS	A	B	C
A	76.6	4.9	18.5
B	0.0	95.3	4.7
C	0.0	0.0	100.0

Class A. Field, Building, and Road
Class B. Forest
Class C. Field

DISCUSSION

The relaxation results for Scene A, shown in tables 1 and 2, demonstrate a definite improvement over the classified results; whereas, three classes of Scene B worsened when relaxed. Most of the error associated with Scene B occurred when class 6 (light forest) and class 2 (scrub) were interpreted as class 1 (heavy forest). Neither the relaxed results of Scene A nor those of Scene B were as good as those obtained in the Research Note ETL-0280. The reason for this is that the referenced values pertained to homogeneous regions; whereas, in these tests the effects of misclassified points at and near the region boundaries leaked into the test regions. Also, the relaxation process was iterated six times, thus allowing more distant points to have an influence on determinations made in the test regions.

The purpose of the relaxation process is to remove noise and, in general, to promote consistency. For the most part, this was accomplished, but at some expense and in some cases by emphasizing noise. For example, consider the boundary between the heavy forest and the fields on the left side of Scene A (see figures 3 and 4). The boundary was interpreted as a road by the classification process. Part of the misclassification problem is due to using large (15 x 15) sampling windows. The incorrectly classified road was intensified in the relaxation exercise. Note that the yellow boundaries shown in figures 7 and 8 and figures 9 and 10 are false colors induced by a misregistration of the TV red and green guns. The boundaries are not representative of a class, nor are the faint magenta regions at the intersections of red and blue, nor are the faint cyan regions at the intersections of green and blue.

Future work will utilize raster processing methods to remove noise and to enhance features. This operation will provide a comparison between interactive repair of derived features and an automated method. Each of the classes can be represented as a binary picture in raster format, wherein blob removal, line shrinking, line growing, and region growing can be used to clean up the scene in an interactive mode. In fact, code is now being developed on the STARAN component of DIAL for this purpose.

Resolution of the output can be improved by using smaller windows to extract texture measures. Note that a 9 x 9 window is too small for the 14-component Max–Min measure used in this experiment. This fact is demonstrated in the confusion matrix results in appendix D of the referenced Research Note ETL-0280. The 15 x 15 windows used in these tests result in 14-meter-squared footprints on the ground. Such a sampling procedure will isolate large textured areas, but it cannot segment small regions even if the Max–Min measure is particularly sensitive to the pertinent image texture.

There is concern that image texture is not a well-defined concept and that perhaps more easily computed functions of the gray shades will produce signatures equal to or better than Max–Min or any one of a large number of defined measures for image segmentation.[4] An attempt will be made to use smaller sampling windows and simpler window functions to develop class signatures. Relaxation processes and raster processing will be applied to the derived data to determine if the simpler approach is equal in accuracy and consistency to the more complex approach.

The impression to date is that the quality of the results does not warrant the amount of computing time necessary to achieve those results. The Max–Min texture signature used here is quite expensive (14 components). However, it is believed that comparable results could have been achieved with fewer components derived from smaller sampling windows. Future work at ETL will be directed toward developing simpler class signatures, wherein refinement will be attempted through interactive raster processing, possibly in conjunction with probabilistic relaxation. Also, it appears that a rule-based process must be developed to remove artifacts such as road-like entities at certain class boundaries. The rule-based process must not only be able to distinguish between false and actual road images but also be able to complete partially delineated real images. Note the missing road portions on figure 3. Those gaps were caused by obscuring forest detail.

CONCLUSIONS

1. Simpler class signatures than Max–Min should be developed from smaller sampling windows and tested for scene segmentation.

2. Interactive raster processing should be investigated to refine classification results and to remove noise.

3. Rules need to be developed to verify classification results and to combine those results with data base entities and with other image functions.

[4]Robert M. Haralick, "Statistical and Structural Approaches to Texture," *Proceedings of the IEEE*, Vol. 67, No. 5, May 1979.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ETL-0300	2. GOVT ACCESSION NO. AD-A123496	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SCENE CLASSIFICATION RESULTS USING THE MAX-MIN TEXTURE MEASURE		5. TYPE OF REPORT & PERIOD COVERED Research Note
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Michael A. Crombie Robert S. Rand Nancy J. Friend		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer Topographic Laboratories Fort Belvoir, VA 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 4A762707A855 B 00026
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer Topographic Laboratories Fort Belvoir, VA 22060		12. REPORT DATE July 1982
		13. NUMBER OF PAGES 27
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Confusion Matrices
Max–Min Texture
Maximum Likelihood Classification
Probabilistic Relaxation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The practicality of using the Max–Min texture measure as a class signature followed by probabilistic relaxation is tested. The results indicate that a simpler texture signature should be developed and that rules need to be developed to verify classification results and to combine those results with data base entities and with other image functions.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)